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THE EFFECT OF COLOR AS A VISUAL AID IN
MATHEMATICS INSTRUCTION

by
Jennifer L. Valinote

A Thesis

Submitted in partial fulfillment of the requirements of the
Master of Science in Teaching Degree

of
The Graduate School
at

Rowan University
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Approved by _____
Professor

Date Approved July 1, 2002

ABSTRACT

Jennifer L. Valinote
THE EFFECT OF COLOR AS A VISUAL AID IN
MATHEMATICS INSTRUCTION

2002

Dr. Randall Robinson
Master of Science in Teaching

The purpose of this study was to determine if fifth grade students who were exposed to colorful symbols and numbers during mathematics instruction would have significantly higher achievement than those students who were taught without the use of colorful symbols and numbers. The sample used in this investigation consisted of two heterogeneous fifth grade mathematics classes. Students in both groups were given pre-tests on the multiplication and division of fractions. After the pre-test the subjects that comprised the experimental group received a three week treatment. The subjects that comprised the control group were taught the same lessons, yet not exposed to colorful symbols and numbers during this instruction. Post-test were then given to the experimental group and the control group. The t-test for independent samples was used to find and statistical significance between pre-test and post-test scores. At $\alpha = .05$, it was found that the null hypothesis used in the research could not be rejected. There was no significant difference in achievement between the students exposed to the use of color as a visual aid and those who were not. Many limitations could have hindered the resultant data. Future research of the effectiveness of color as a visual aid in mathematics instruction is recommended.

MINI- ABSTRACT

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2002

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The purpose of this study was to determine if there was a significant relationship between the use of color as a visual aid during mathematics instruction and student achievement levels. It was found that there was no significant difference between fifth grade students who were exposed to colorful symbols and numbers during mathematics instruction and those students who were not.

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I would not have been able to complete this task without the help of a very special professor at Rowan University. Dr. Randall Robinson has been my teacher, my advisor and even my “coach”. He has encouraged me when I thought I had nothing left to give. He has inspired me to be the kind of teacher who makes a difference and one who reaches all students. Since the first day of this seemingly impossible MST program my goal has been to make him proud. It is my hope that as I complete this investigation and begin my teaching career, I have accomplished this.

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Chapter I

Scope of the Study

Introduction

Students throughout the years have been taught their daily lessons with the aid of a chalkboard. The chalkboard is a medium that consists of a dark background, of either green or black, with white writing from the chalk. Although visually presenting information to students does aid in learning, this is the only medium in our society that presents information in this manner (Goodman & Cundick, 2001).

Much research has investigated the use of color in the classroom, and it's effectiveness as a teaching aid. Color is often used in the printing of children's books, and in reading schemes and other educational materials designed for both children and adults (Malliet, 1986). Mediums in society like newspapers, books and magazines all present information on a light background with dark or colorful writing. Yet students are expected to gather and process information in the classroom that is provided in a colorless manner. Information given in the classroom on a chalkboard lacks color, and is therefore not similar to the information they are presented with on television, or in magazines, and children's books (Richards, 1984).

Elementary school students are relatively new to learning. They are quite familiar, however, with television, children's books, and computer programs, all of which use color to attract attention and highlight important information (Mucha, 2001). Due to the popularity and frequency of these mediums it seems clear that color is a potent

stimulus for young children, and should therefore be used in the classroom in order to foster student learning (Richards, 1984).

Research shows that there are many ways color can aid in learning. It seems that color aids students in learning by arresting their attention (Cruickshank, 1967). Research also suggests that color is useful as a mnemonic device which makes the material more meaningful, and helps in the retention of material to be learned (Watts & Nisbet, 1974). Research has also illustrated that the use of color helps learners by providing an associative structure (Lamberski & Dwyer, 1983).

With the amount of research compiled on the effectiveness of color as a visual aid, as Gineva Malliet states in her research, “the question seems to be not so much whether color should be used at all...but rather how much color should be used” (1986).

Rationale for the Study

There is a myriad of techniques that teachers utilize during instruction in order to help students process and retain important information. Many studies have shown that using color as a way to highlight specific information aids significantly in student learning (Malliet, 1986). Using color in instruction is especially beneficial because there are many different ways students in classrooms today learn (Elliot, 1980). Color as a visual aid in the classroom encourages students to use not only the left-side, or analytical part of the brain, but also the right-side, or creative part of the brain. As Ausubel and Robinson have stated in their research, “meaningful learning can and should take place in both hemispheres of the brain” (1969).

Though the studies focused on utilizing color when teaching mathematics are few, there are numerous studies that show the power of color as a visual aid in language arts

skills. This quasi-experimental study was an effort to determine if using color in mathematics instruction would significantly affect the achievement of fifth grade students.

Statement of the Research Problem

The purpose of this study was to investigate the effect colorful symbols and numbers during a standard math lesson had on the achievement of fifth graders. The research conducted addressed the following questions:

1. Will the use of color during mathematics instruction improve fifth grade students' understanding, and therefore, achievement in specific mathematical skills?
2. Is there a significant relationship between color and student achievement?

Statement of the Hypothesis

There will be no significant difference in the achievement level of fifth grade students on a mathematics test who are taught mathematical skills with the use of colorful symbols and numbers on a white board and the achievement level of fifth grade students on a mathematics test who are taught the same mathematical skills without the use of colorful symbols and numbers on a white board.

Limitations of the Study

There were several limitations of this inquiry:

One of the limitations of this study was the ability of students to transfer from colored symbols and numbers on the white board, to plain black and white symbols and numbers on paper. Since colored pencils or markers were not available to the students when taking a test, this factor may have affected the students' achievement. This is due to the fact that during instruction the students had associated certain colors with

mathematical procedures, and the lack of color on the test could have complicated their thinking.

A second limitation of the study was the use of a small sample. This sample was only two elementary classrooms, consisting of 20-25 students each. This may have effected the external validity of the study, since a larger sample would possibly have more relevance. The external validity could have also been effected since this inquiry was limited to one school district and one grade level. Limiting the study to one school district and grade level hinders its implications in other school settings.

Another limitation was that the subjects in the study were not selected randomly, because the researcher was limited to her assigned classes.

Lastly, the amount of time allowed for the treatment in the experimental classroom was limited to three weeks. This is not a significant amount of time for students to be exposed to the treatment. For more definitive data, a longer treatment is recommended.

Definitions of Terms

These terms were used frequently throughout the study and were defined as follows:

Achievement – amount of learning measured by the range of scores of the students participating in the study on pre-tests and post-tests.

Colorful numbers – the common characters found in mathematics, which represent distinct amounts, which for the purpose of this study were blue digits for multiplication and red digits for division.

Colorful symbols – the common characters found in mathematics which represent specific operations such as: \times (multiplication), \div (division), $+$ (addition), $-$ (subtraction), and $=$ (equals), which for the purpose of this study were blue symbols for multiplication, and red symbols for division.

Mathematical skills- multiplying and dividing regular fractions, improper fractions, and mixed numbers.

Chapter II

Review of Related Literature

Introduction

In today's classrooms there are a variety of learners. Due to this fact, research has been conducted in an effort to provide educators with specific techniques to ensure that all students in a classroom can succeed. In analyzing research on how students learn, it has been supported that the brain processes information in two different ways. These two ways of processing information, sequentially and simultaneously, and more commonly known as left brain/ right brain processing. (Grevenow, 1988). Presently the educational system used in the United States focuses on left brain instructional techniques (Grevenow, 1988).

In an effort to investigate teaching techniques that reach a greater majority of students, much research has been conducted on ways to involve both hemispheres of the brain during classroom instruction. In Ronald Rubenzer's (1982) research on the importance of incorporating both the left brain and right brain activities in learning, he states that "steps toward dealing with the whole child in the educational system should incorporate consideration of teachers' ...general strategies which more fully involve the brain in learning". One such technique that incorporates both the left side and the right side of the brain in learning is the use of color as a visual aid (Richards, 1984).

This quasi-experimental study attempted to analyze the use of color as a visual aid in mathematics instruction, and if there is a significant relationship between the use of color in instruction and the achievement of fifth grade students. The researcher hypothesized that there will be no significant difference in the achievement level of fifth grade students on a mathematics test who are taught mathematical skills with the use of colorful symbols and numbers on a white board and the achievement level of fifth grade students on a mathematics test who are taught the same mathematical skills without the use of colorful symbols and numbers on a white board. It is important to examine all techniques available to educators that may provide to students more clarity, which in turn, makes higher achievement possible. It is evident when reviewing color related research that “color coding helps learners organize or categorize information into useful patterns which enables the learners to interpret and adjust to their environment” (Dwyer & Moore, 1995). Color, as a visual aid is an extremely important technique to research because teachers of all subject areas can readily apply it (Grevenow, 1988).

History of Color Used in Education

Color has been involved in education for quite a long time. In fact, it has been reported that color and its effectiveness in learning has been extensively researched since 1935 (Malliet, 1986). These studies primarily focused on color as it relates to the attentional and automatic aspects of cognition (Ibid). Color reading schemes have been used dating as far back as the 1890's when N. Dale introduced color as a learning aid for word recognition in his book *Reading By Rainbow and Colour Story Reading*. More recently Gattegno developed a similar system described in his book, *Words in Color*.

This system was the first to use color-coding to encompass all of the phonic possibilities in the English language.

Although the investigations analyzing the effectiveness of color used in educational materials have been significant, it has also been reported that the effectiveness of color decreases as the level of cognitive task increases (Lamberski & Dwyer, 1983). Using too much color as a learning tool can also hinder its effectiveness. J. Kanner (1968), in his research concluded: "as the number of color-coded items in a visual display increases, the usefulness of color as a cueing agent decreases". As this research suggests, color as a visual aid in instruction would seem most helpful to students in the primary levels, where cognitive tasks are still simplistic. Furthermore, the frequency of color in instructional materials is seemingly most beneficial when not overused.

Children's Associations with Color

Perhaps a reason color is such an effective learning tool for children is the positive association many have with bright colors. For example, as Peter Mucha commented in a recent article for the Philadelphia Inquirer, "Big Bird and the Simpsons are yellow, Cookie Monster and the Smurfs are blue, Elmo is red and the Pink Panther is well, you know" (2001, October 28). Children in the elementary grades have grown up watching characters on television, and reading about them in books that are bright and colorful, and thus, they develop a fondness for colorful things (Malliet, 1986).

Adding color in the classroom, specifically for visually presenting information seems to be in agreement with how children learn. In an experiment where 3 and 4 year old children were unable to identify the color of a given object, they were comfortable re-

naming these objects with the colors they were more familiar with, such as purple for mauve, green for chartreuse, and white for flaxen (Terry, 1988).

Color can be used in educational materials for children to not only facilitate learning, but also to help stimulate their interest and imagination. In Barbara Grevenow's research she reiterates the impact color has on children by stating: "Since children ...are often visual learners, using color whenever possible can be especially helpful in teaching them. These children are attracted to bright colors and often react emotionally to them" (1988, pg.18).

The research suggests that color is already an important and comforting fixture in a child's everyday life. Adding color to aid in instructing these students in the classroom also has been shown to enhance the motivation, attention, and long-term and short-term memory of these young learners (Cruickshank, 1967).

Although research has been completed that tests color's effectiveness on older subjects, it seems as though color is most beneficial to the younger learners. As noted in Lamberski & Dwyer's study (1983), color codes seem to be most useful in low-level cognitive tasks, such as sorting, when externally paced materials are used. These "low-level cognitive tasks" would most often include children in the elementary levels, as cognitive skills increase as students progress to higher-grade levels.

The Effect of Color on Memory

The support for using color to aid in educational contexts is overwhelming. This is mainly due to the fact that color has been shown, in numerous experiments, to aid significantly in the memory and recall of information. It was found in a study by Winters & Hoats (1984) that words isolated by color in a sentence-like format facilitated

immediate recall of those words in 36 retarded and non-retarded persons of similar mental age. It seems as though color is beneficial to all types and levels of learners. This is a meaningful finding considering that the modern day classroom has many levels of students, some of whom are classified with specific learning disabilities (Grevenow, 1988).

Experiments with color have shown to aid in children's long term recall. Farley & Grant (1976) used a slide presentation containing both black and white and color pictures that proved, not only on immediate retention tests, but also on tests given 7 days later, that color significantly aided the subjects' recall. As Malliet states in her research on color and memory, "Claims are also made for the usefulness of color as a mnemonic device which makes material more meaningful and aids in the retention of material to be learned" (1986, pg. 3). These empirical findings show that color not only grabs the attention of the learner, it also helps facilitate memory.

The Effect of Color on Learning

In every level of education color is an important aspect of learning. Color is used regularly in textbooks, visual aids and study materials. Color is frequently used as an educational tool because it helps to highlight important information. As Regina Richards (1984) noted in her speech presented at the Annual Convention of the Council for Exceptional Children in Washington, DC, using color in the classroom helps to emphasize and exaggerate instruction. She addresses the benefits of this technique by adding: "By exaggeration we may overstate, or increase the intensity through verbal or visual means. Emphasis forces concentration and highlights specific areas. It is a tool

which endeavors to reach all students with all kinds of learning styles. Color, size, humor are critical tools for exaggeration.” (pg. 7).

Color is an effective strategy to use in learning because it provides students with the ability to “enhance or sharpen essential message characteristics by providing structures for the storage of new information” (Dwyer, 1978, pg. 176). When reviewing the various experiments that test the effectiveness of color as a visual aid vs. traditional black and white aids, it is accepted that color facilitated student achievement (Dwyer & Moore, 1995).

In a study that examined if there was a significant relationship between color and a child’s ability to learn unfamiliar letters, Lamberski and Dwyer (1983) found that the use of color did facilitate retention on both immediate and six-week delayed testing. The researchers in this study further concluded that the value of using color to aid in learning provides a structure for physical discrimination and associative meaning in self-paced instruction. At the end of their research Lamberski and Dwyer (1983) recommended that their conclusions on the effectiveness of color as a learning tool was equally applicable to older learners and should not necessarily be generalized to younger learners. This discovery supports the rationale that, no matter the age level, educational materials such as textbooks, which are designed with color to highlight information, are valuable in learning.

A problem often cited in research pertaining to color as a visual aid is a student’s ability to transfer from the colored material to black and white material. Goodman and Cundick (1976) found in their research that, the subjects, after initially learning faster

with the colored materials, experienced difficulty in transferring this knowledge to the traditional format of black and white.

In another experiment involving the effectiveness of color, the researchers found that when utilizing a color code for vowels only, the subjects' ability to learn the spelling of irregularly spelled and nonphonetic words increased. In the same study, however, it was also concluded that the children struggled with transferring the nonphonetic words from color to black (Turner, 1984).

It is important to observe whether or not utilizing specific colors for distinctive numbers, symbols and mathematical operations is beneficial, considering this technique cannot be duplicated by the students on assessments (Goodman & Cundick, 1976).

Color in Language Arts Instruction

Experiments to determine the effectiveness of color as a visual aid is most frequent in language arts instruction. Perhaps a reason for this is the finding that using the right side of the brain, or simultaneous processing, "is used in remembering the configuration and shape of letters in a word and in generalizing and applying spelling rules" (Grevenow, 1988, pg. 10). There are many methods teachers can use in the classroom to engage this simultaneous processing needed. Color is one such teaching technique with much empirical support (Richards, 1984).

In numerous studies where the subjects were presented with the task of learning unfamiliar letters the researchers found that: "color coding used with a progressive fading of colors might well make initial learning in reading much more rapid" (Goodman & Cundick, 1976). This finding is especially significant to educators in the primary grades,

as research shows that color is successful in aiding students' recognition of new letters and words in their reading materials (Goodman & Cundick, 1976, pg. 70).

Further investigation into the usefulness of color in the acquisition of language arts skills shows that subjects were able to learn colored letters in fewer trials than they were able to learn black letters (Goodman & Cundick, 1976). The researchers in this study concluded that implementing the use of color: "during the initial phases of learning" was most beneficial, and that color caused the subjects' reading progress to be more rapid, and their initial letter discriminations to be easier, with less likelihood of orientation errors (Goodman & Cundick, 1976).

Another interesting study focused on the power color has in language arts skills. It was found in several studies that major interference occurs when subjects are presented words written in an incongruent color. For example, the subjects experienced difficulty when they were asked to identify the blue ink color used to print the word "grass" (Klein, 1964). Investigation as to why this interference occurs in color-related words is best summed up in research which states: "it is clear that even when subjects are asked to ignore the word printed on the card, automatic processing still occurs" (Malliet, 1986). Although the exact brain processing involved in this interference is not fully understood, this tendency to incorrectly name the ink color of incongruent words is considered "an important means for increasing our understanding of the normal process of reading, stimulus identification and stimulus meaning" (Dwyer, 1972).

An explanation, however, as to how color aids students so significantly in other language arts skills is summed up in research which expounds: "color-coding would attempt to compensate for the restructuring skills absent...and lead to deeper information

processing and increased achievement” (Dwyer & Moore, 1995). This empirical finding coupled with a child’s inherent positive associations with color make a strong case for the further investigation into techniques teachers can implement in the classroom that utilize color as a visual aid.

Color in Mathematics Instruction

Due to the proven effectiveness of color as a visual aid in language arts instruction, the examination of techniques that incorporate the use of color in mathematics instruction is equally important. It has been determined that many schools currently rely on left-brain teaching techniques which do not provide success to those students whose processing prowess necessitate teaching techniques that utilize the right-side of the brain. (Grevenow, 1988). Researching methods to reach these students is imperative, as conservative estimates show that nationally, there are between two and three million students in grades K-12 who are predominately right brained in their learning style (Rubenezer, 1982).

Investigation into the effectiveness of color as a visual aid is needed, as many researchers believe, due to that fact that: “if schools in general and mathematics classes in particular systematically under-utilize the right half of the brain, the learning capacities of all our students will be subsequently reduced by half” (Elliot, 1980). Furthermore, as Grayson Wheatley (1977) contends in *Arithmetic Teacher* magazine: “early and continued emphasis on rules and algorithms (primarily linear and sequential tasks) may inhibit the development of creativity, problem solving, and spatial abilities.”

Mathematics is a skill that requires students to understand and compute both concrete and abstract relationships (Grevenow, 1988). The use of color in mathematics

instruction fosters the use of a student's simultaneous processing, or right side of the brain. In particular, mathematical skills like place value, addition, and subtraction all rely on simultaneous processing by students. Higher level mathematical skills like fractions, geometry and measurement require students to be strong in both simultaneous and sequential processing (Grevenow, 1988).

Experimentation on the effectiveness of color in mathematics instruction is limited. There are findings that illustrate using color in mathematics instruction has a positive correlation with students' interest, behavior and achievement in the classroom (Grevenow, 1988). Research has also shown a significant decrease on the number of children in a classroom who felt frustrated in their attempts to learn (Grevenow, 1988). The effectiveness of using color in mathematics instruction is not as explored as it is in language arts instruction. Yet there is much empirical support to document the power of color on memory, and in learning. It seems beneficial to examine teaching methods that can positively affect a student's achievement in mathematics.

Chapter III

Procedure and Design of the Study

Introduction

The purpose of the study was to analyze if color had an effect on students when learning specific mathematical skills. With the wide variety of learners in today's classrooms, this investigation was designed to analyze the effect color as a visual aid had on student achievement in mathematics (Grevenow, 1988).

As Barbara Grevenow found in her research, implementing color as a visual aid in the classroom would help stimulate those students that are more "simultaneous learners", and who do not benefit from the traditional sequential methods of instruction and learning. Grevenow states in her research, "By using teaching methods which provide a balance of both sequential and simultaneous cognitive processing, teachers would be more likely to reach every child in their classroom" (1988).

This study examined fifth grade students who were exposed to colorful numbers and symbols on a white board during mathematics instruction. The experiment determined if these students would have significantly higher achievement scores than those fifth grade students who were not exposed to colorful numbers and letters on a white board during mathematics instruction. The researcher hypothesized that there will be no significant difference in the achievement level of fifth grade students on a mathematics test who are taught mathematical skills with the use of colorful symbols and

numbers on a white board and the achievement level of fifth grade students on a mathematics test who are taught the same mathematical skills without the use of colorful symbols and numbers on a white board.

Population and Sample

The school district used in this study consisted of eight schools. Six of these were elementary schools containing kindergarten through fourth grades. Of the remaining two schools, one was an upper elementary school, containing grades five and six, and the other was a middle school, which contained grades seven and eight.

This study was conducted in the upper elementary school which housed approximately 1500 fifth, and sixth grade students. The school district was located 30 miles east of a metropolitan area. The town was a middle-class area where the average income of the residents is \$23, 248. The student population in this district was roughly 89% Caucasian, 6% African American, 2% Asian and 1% Hispanic.

The sample in this study consisted of two heterogeneous fifth grade classes. These subjects were taken from a larger population of the upper elementary school.

The experimental group of this study consisted of 21 students, of which, 11 were female, and 10 were male. Sixteen of the students in this classroom were Caucasian, four were African American, and one was Asian. This class had performed all year in mathematics, and their classroom averages were 89%, 92% and 86% for the first three marking periods of the 2001-2002 school year.

The control group of this study consisted of 23 students. In this group there were 12 females and 11 males. Of these subjects, 21 were Caucasian and 2 were African American. The mathematical ability of this group throughout the year was evident in

their averages of 83%, 85% and 82% in the first three marking periods of the 2001- 2002 school year.

Experimental Design and Procedure

For the purposes of this study two fifth grade mathematics classes were used, one as an experimental group, and the other as a control group. Both the experimental and the control classes were given pre-tests on multiplying and dividing fractions (*see appendix A*).

The subjects were given one whole class period, or forty minutes, to complete the pre-test. Each subject in the study used a “privacy folder” when taking the pre-test so that others would not be able to see their answers. Most subjects finished the pre-test before the allotted forty minutes had expired.

After the pre-test both the experimental group and the control group were given specific mathematics lessons on the multiplication and division of fractions. These lessons were exactly alike in content and were taught by the researcher. The subjects in the experimental group were instructed during the lessons that blue symbols and numbers on the board represented multiplication, and red symbols and numbers on the board represented division. The control group was instructed with only the use of black symbols and numbers (*see appendix C for lesson plans*).

After a three-week treatment the subjects from both groups were given the post-test (*see appendix B*). Scores on the post-tests were analyzed and compared to scores on the pre-tests to see if there was significant effect on the achievement level of fifth grade students who were taught mathematical skills with the use of colorful symbols and numbers on a white board.

Description of the Instrument

The pre-test used in this study consisted of sixteen mathematical questions. The first six questions on the pre-test consisted of fraction multiplication. There were four different types of multiplication used in this section. These were: multiplying fractions by fractions, multiplying fractions by whole numbers, multiplying fractions by mixed numbers, and multiplying mixed numbers by mixed numbers. Four questions on the test required the students to estimate the product of fractions multiplied with fractions, fractions multiplied by whole numbers, and mixed numbers multiplied by whole numbers. One question on the pre-test required the subjects to solve a word problem. The remaining six questions on the pre-test required the subjects to divide fractions. The different types of division questions used on the pre-test were: dividing fractions by fractions, dividing fractions by whole numbers, dividing fractions by mixed numbers, and dividing mixed numbers by mixed numbers (*see appendix A*).

Chapter IV

Analysis of Findings

Introduction

Research has shown that teaching techniques that utilize both the right and left side of the brain are most beneficial to students (Richards, 1984). In an effort to include the right side of the brain in more classroom activities much research has focused on the use of color during instruction as a visual aid. This method has been found especially effective in language arts based skills such as letter identification, spelling and reading (Goodman & Cundick, 1976).

Utilizing color in mathematics instruction, although not as researched as in language arts instruction, has also proven to be not only important, but also effective. It is important for educators to implement teaching methods that engage the right side of the brain in mathematics education. The importance of color, and other methods that utilize the right side of the brain in mathematics instruction were further illustrated by Portia Elliot (1980). In her article she explains, “over-emphasizing computational skills (thought to be a left hemisphere activity), teachers allow skills in problem solving (thought to require right and integrated thinking) to go undeveloped. By emphasizing rote learning (verbatim learning- a left hemisphere activity), the opportunities for meaningful learning are diminished.”

As far as color’s effectiveness in instruction, Barbara Grevenow (1988) noted in her research that, “it was concluded that the techniques definitely improved the academic

growth, attitudes, and classroom behaviors of the children.” More current experimentation is needed to test if color as a visual aid can engage the right side of the brain, and bolster achievement in mathematics (Richards, 1984).

The purpose of this study was to determine if the implementation of color as a visual aid in mathematics instruction would have a significant effect on the achievement of fifth grade students. The hypothesis used by the researcher was that there will be no significant difference in the achievement level of fifth grade students on a mathematics test who are taught mathematical skills with the use of colorful symbols and numbers on a white board and the achievement level of fifth grade students on a mathematics test who are taught the same mathematical skills without the use of colorful symbols and numbers on a white board.

This subjects used for this investigation consisted of two heterogeneous fifth grade mathematics classes. Before the implementation of the treatment both groups took a pre-test on the multiplication and division of fractions, a skill in which the fifth grade students had no prior schooling. The experimental group was then exposed to a three-week treatment where lessons on the multiplication and division of fractions were taught with the aid of red and blue markers on a white board. The control group was taught the same lessons with the use of a black marker on a white board. After the treatment both groups were given post-tests. This data was then analyzed to see if there was a significant difference between the achievement level of the two classes.

Tabulation of Raw Scores

Scores from the experimental and the control groups' pre-tests and post-tests were analyzed and used for the calculation of raw scores. A constant was added to all scores

on these tests in order to account for any negative raw scores. This enabled all data to be positive. The pre-test raw scores show that both the experimental group and the control group were close in mathematical ability. The mean scores for the experimental and the control groups were 11.63 and 11.95, respectively. The standard deviation of scores was 1.46 for the experimental group and 1.53 for the control group. These figures are illustrated in table 1:

table 1
Raw Scores Pre-Test

Group	Number of Scores	Standard Deviation	Mean
Experimental	19	1.46	11.63
Control	22	1.53	11.95

The post-tests were also examined for the standard deviation, as well as the mean of scores. The experimental group's mean score was 25.89, where the control group's mean score was slightly lower at 25.27. The standard deviation of scores for the experimental group was 1.05, the standard deviation for the control group was 1.55. This data is illustrated in table 2:

table 2
Raw Scores Post-Test

Group	Number of Scores	Standard Deviation	Mean
Experimental	19	1.05	25.89
Control	22	1.55	25.27

Tests of Significance

The experimental and the control groups were both analyzed separately using the t-test for nonindependent samples to examine if the amount learned was significant. Each test was conducted at $\alpha=.05$. For the experimental group, the t-value was 35.35 at 18 degrees of freedom. For the control group, the t-value was 31.09 at 21 degrees of freedom. The data suggested that the amount learned was higher in the experimental group. These findings are listed in table 3:

table 3
t-Test Amount Learned

Group	t-value	Degrees of Freedom
Experimental	35.35	18
Control	31.09	21

In order to evaluate if the use of color in mathematics instruction had a significant effect on the students' achievement on the post- test, the t-test for independent samples at $\alpha=.05$ was used. This analysis determined whether or not the null hypothesis used by the researcher could be rejected. On the post-tests the t-value was 1.48 at 39 degrees of freedom. With these figures and $\alpha=.05$, the null hypothesis could not be rejected. Table 4 illustrates this data:

table 4

t-Test Post-Test Scores

t-value	Degrees of Freedom	Reject Null Hypothesis
1.48	39	No

Analysis of Data

For the purposes of this investigation the researcher hypothesized that there would be no significant difference in the achievement level of fifth grade students on a mathematics test who are taught mathematical skills with the use of colorful symbols and numbers on a white board and the achievement level of fifth grade students on a mathematics test who are taught the same mathematical skills without the use of colorful symbols and numbers on a white board. When examining the data collected for the purposes of this study, the null hypothesis could not be rejected. Although the figures suggested that there was a more significant amount learned in the experimental group than in the control group, it would not be accurate to assume that the color used in the mathematics instruction during the treatment caused this.

Chapter V

Summary, Conclusions, and Recommendations

Introduction

Educators are in constant search for methods to use in the classroom that help aid the variety of learners in the classrooms of today (Richards, 1984). Special attention has been paid to the way students learn, and specifically to what hemispheres of the brain (left or right) are being used during instruction (Grevenow, 1988). Studies like these are important because, as Ronald Rubenzer (1982) states in his research, “steps toward dealing with the whole child in the educational system should incorporate consideration of... general strategies which more fully involve the brain in learning.” One such meaningful strategy that can be utilized in the classroom is implementing color as a visual aid (Richards, 1984).

Research shows that color is a strong visual stimulus that can aid in learning. Color aids students in learning by arresting their attention (Cruickshank, 1967). Studies have shown that color is useful as a mnemonic device which makes educational material more meaningful, and helps in the retention of material to be learned (Watts & Nisbet, 1974). Color when used as a visual aid during instruction helps learners by providing an associative structure (Lamberski & Dwyer, 1983).

Finding alternative methods of presenting information in the classroom, like color as a visual aid, could illicit from the students: more interest in the subject matter, better

classroom behavior, more confidence in skills learned, and higher achievement levels on various assessments (Grevenow, 1988).

Summary of the Problem

This quasi-experimental study examined the effectiveness of color as a visual aid in mathematics instruction. The experiment analyzed if the implementation of color during mathematics instruction had a significant impact on the achievement level of fifth grade students. The research was centered on the following questions:

1. Will the use of color during mathematics instruction improve fifth grade students' understanding, and therefore, achievement in specific mathematical skills?
2. Is there a significant relationship between color and student achievement?

Summary of the Hypothesis

The hypothesis used for the study stated that there will be no significant difference in the achievement level of fifth grade students on a mathematics test who are taught mathematical skills with the use of colorful symbols and numbers on a white board and the achievement level of fifth grade students on a mathematics test who are taught the same mathematical skills without the use of colorful symbols and numbers on a white board.

Summary of the Procedure

Two heterogeneous fifth grade classrooms of an upper elementary school located in southern New Jersey were used as the subjects in this study. These classrooms were comprised of approximately twenty students each, with comparable mathematical skills. One classroom was chosen as the experimental group, and the other was used as the

control group. Both classes were taught by the researcher to ensure consistency in instruction.

Both the experimental and the control group were given pre-tests on the multiplication and division of fractions at the beginning of the study. This mathematical skill was one in which the students had no prior instruction. A constant was added to all pre-test scores in order to accommodate for any negative data.

The treatment lasted three weeks, and included the use of specific colors during instruction. The subjects in the experimental group were informed that questions regarding the multiplication of fractions would be written in blue marker on the white board. Questions regarding the division of fractions were written in red marker on the white board. During instruction for the control group, all questions regarding the multiplication and division of fractions were written in black marker on the white board.

At the end of the three week treatment both groups were given a post-test. The post-test used was identical in content to the pre-test used. The researcher scored both the pre-tests and the post-tests. The mean and standard deviation for each group was calculated on the pre-test and the post-test. The amount learned by each group was also tabulated based upon the differences in scores from pre-test to post-test. T-tests for independent samples were used to analyze this data for any significant findings.

Summary of Findings

The findings of this study show that there is no significant difference between the achievement of fifth grade students who are exposed to colorful symbols and numbers on a white board during mathematics instruction, and the achievement of fifth grade students who are not exposed to colorful symbols and numbers on a white board during

mathematics instruction. Therefore, the null hypothesis used by the researcher in this investigation cannot be rejected. This study found there to be no statistical significance in using color as a visual aid during mathematics instruction. Perhaps further investigation and a longer treatment period would provide more conclusive data on the effectiveness of color in mathematics instruction.

Conclusions

The data collected in this study concluded that there is no significant difference between the scores from the experimental group and those scores gathered from the control group. However, the average of the experimental groups post-test scores are higher than the control groups' post-test scores. Although the t-tests used to analyze this difference found it to be of no statistical significance, this is an important finding for educators. Teachers are constantly in search of instructional methods that will reach more students. This study showed that the use of color in a classroom may be beneficial due to the fact that the experimental group did show greater improvement in scores from pre-test to post-test.

There were also limitations in the study that may have affected its statistical impact. One of the most restrictive limitations was that the length of time allowed for the treatment was very short. If the students in the study were instructed using color for a longer period of time, the research may have proven to be more indicative.

Another limitation was the small size of both groups. It would be easier to find some statistical significance using a much larger sample, as there would be less room for uncontrollable circumstances like student absences and unplanned school activities that can interrupt classroom instruction. It is also not known how much of a factor it was for

the subjects in the experimental group to transition from seeing colorful symbols and numbers on the white board, to plain black symbols and numbers on the post-test. These limitations create the need for further investigation on color's effectiveness in the classroom.

Implications and Recommendations

The findings of this study cannot confirm the relationship between the use of color as a visual aid in mathematics instruction, and the superior post-test average of the experimental group as significant. However, this study does create many questions as to the effect color can have on students when used during instruction. Observations made by the researcher during the treatment highlighted that the students taught with the use of color were more enthusiastic about the instruction and, in class, seemed to show more mastery of the skill than the control group. These observations may seem slight, but again, can be of benefit to other educators looking for techniques to reach a greater majority of their class. Furthermore, the data in this study showed that there was no negative relationship between the use of color during instruction and achievement level. This finding was also important because educators should feel confident implementing color in their instruction, as it was not proven to be a hindrance to students.

The intent of this study was not to radically change the way educators present information to students during instruction. This study was intended to test an alternative teaching method that could be used as a supplementary technique in the classroom. In modern classrooms there is a variety of abilities among learners. Many students are classified as learning disabled, and require extra services from their teachers. Using color in the classroom does offer alternative ways of presenting information to students. It is

important for teachers to investigate all alternative teaching techniques available in order to better reach the students. The findings of this study, although not entirely conclusive to the benefit of color, do warrant further investigation into the effectiveness of color as a visual aid in mathematics instruction.

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Appendix A

Pre-Test

Name _____ # _____ Date _____

Multiplying and Dividing Fractions PRE-TEST

Multiply:

1. $\frac{1}{4}$ of 32 =

4. $\frac{2}{5} \times \frac{3}{8} =$

2. $\frac{3}{5}$ of 15 =

5. $3\frac{1}{4} \times 2 =$

3. $\frac{6}{9} \times \frac{18}{24} =$

6. $1\frac{1}{3} \times 2\frac{1}{2} =$

Estimate:

7. $\frac{5}{9} \times 14 =$

9. $\frac{3}{4} \times \frac{1}{2} =$

8. $3\frac{1}{8} \times 7 =$

10. $\frac{3}{4} \times 25 =$

Divide:

11. $11 \div \frac{1}{4} =$

14. $1\frac{3}{4} \div \frac{4}{5} =$

12. $\frac{1}{5} \div 6 =$

15. $8 \div 2\frac{1}{3} =$

13. $\frac{7}{8} \div \frac{5}{7} =$

16. $1\frac{1}{2} \div 2\frac{3}{4} =$

Work Backwards:

17. Suppose a friend has been playing a board game in which each player begins with a certain number of points. She tells you that she doubled her points on her first turn, she lost 22 points on her second turn, she made 15 points on her third turn, and she ended the game with 33 points. Can you tell me how many points she had when she started? _____

Appendix B

Post-Test

Name _____ # _____ Date _____

Multiplying and Dividing Fractions POST-TEST

Multiply:

1. $\frac{1}{4}$ of 32 =

4. $\frac{2}{5} \times \frac{3}{8} =$

2. $\frac{3}{5}$ of 15 =

5. $3\frac{1}{4} \times 2 =$

3. $\frac{6}{9} \times \frac{18}{24} =$

6. $1\frac{1}{3} \times 2\frac{1}{2} =$

Estimate:

7. $\frac{5}{9} \times 14 =$

9. $\frac{3}{4} \times \frac{1}{2} =$

8. $3\frac{1}{8} \times 7 =$

10. $\frac{3}{4} \times 25 =$

Divide:

11. $11 \div \frac{1}{4} =$

14. $1\frac{3}{4} \div \frac{4}{5} =$

12. $\frac{1}{5} \div 6 =$

15. $8 \div 2\frac{1}{3} =$

13. $\frac{7}{8} \div \frac{5}{7} =$

16. $1\frac{1}{2} \div 2\frac{3}{4} =$

Work Backwards:

17. Suppose a friend has been playing a board game in which each player begins with a certain number of points. She tells you that she doubled her points on her first turn, she lost 22 points on her second turn, she made 15 points on her third turn, and she ended the game with 33 points. Can you tell me how many points she had when she started? _____

Appendix C

Lesson Plans

Lesson Plan # 1

Objective: At the end of the lesson the students will be able to illustrate the multiplication of fractions.

A.S.: Ask the students to volunteer their opinions of the pre-test.

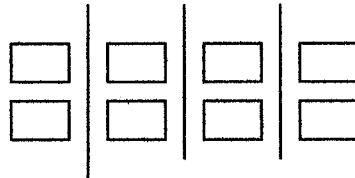
Input: Tell the students in the experimental group that all multiplication problems in this until will be written in blue.

****** Multiplication problems for the control group will be written in black.

Have the students try to illustrate the following problem.

Find: $\frac{1}{4}$ of 8 =

Draw:



Separate the squares into 4 sections.

Count the squares in section # 1 = 2

$$\frac{1}{4} \text{ of } 8 = 2$$

$$\frac{1}{2} \text{ of } 8 = 4$$

$$\frac{3}{4} \text{ of } 8 = 6$$

Modeling: Find: $\frac{2}{3}$ of 9 =

Draw:



Separate into 3 sections (denominator)

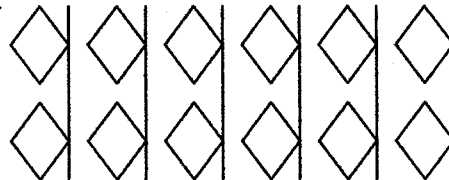
Count amount of shapes are in two groups.

$$\frac{2}{3} \text{ of } 9 = 6$$

Guided Practice:

Find: $\frac{1}{6}$ of 12 =

Draw:



Separate into 6 sections.

Count the amount of shapes in 1 section.

$$\frac{1}{6} \text{ of } 12 = 2$$

Find: $\frac{4}{5}$ of 30 =

Drawing 30 blocks is too much.

Teach students shortcut:

5 (denominator) goes into 30 6 times.

6 times 4 (numerator) = 24.

$\frac{4}{5}$ of 30 = 24

Find (without drawing a picture): $\frac{5}{6}$ of 36 =

6 goes into 36 6 times

$6 \times 5 = 30$

$\frac{5}{6}$ of 36 = 30

Find: $\frac{4}{5}$ of 30 =

5 goes into 30 6 times

$6 \times 4 = 24$

$\frac{4}{5}$ of 30 = 24

Checking for Understanding:

Have the students practice by finding the answers to the following multiplication problems:

1. $\frac{1}{9}$ of 27 = 3
2. $\frac{1}{3}$ of 18 = 6
3. $\frac{3}{4}$ of 16 = 12
4. $\frac{2}{9}$ of 36 = 8
5. $\frac{4}{5}$ of 15 = 12

Lesson Plan # 2

Objective: At the end of the lesson the students will be able to multiply fractions by whole numbers.

At the end of the lesson the students will be able to cross cancel before multiplying fractions by other fractions.

A.S: Review the multiplication of fractions with the students.

*All multiplication questions for the experimental class are written in blue.

*All multiplication questions for the control class are written in black.

REVIEW:

1. Find $\frac{1}{4}$ of $28 = 7$
2. Find $\frac{2}{3}$ of $27 = 18$
3. Find $\frac{3}{8}$ of $24 = 9$
4. Find $\frac{4}{7}$ of $10 = 40$

Input:

Show students another way of solving multiplication questions.

$\frac{1}{4}$ of $28 =$ can also be written as: $\frac{1}{4} \times \frac{28}{1}$

Cross-canceling (diagonally only) can make the problem easier.

4 goes into 4 once

4 goes into 28 7 times

Then multiply across.

$$1 \times 7 = 7$$

$$1 \times 1 = 1$$

$$\frac{7}{1} = 7$$

Guided Practice:

Have the students cross-cancel before solving the following problems:

1. $\frac{2}{3} \times \frac{27}{1} = 18$
2. $\frac{3}{8} \times \frac{24}{1} = 9$
3. $\frac{4}{7} \times \frac{70}{1} = 40$

Checking for Understanding:

Remind the students that they can cross-cancel twice sometimes.

Have the students solve the following problems and state where they cross-cancelled.

Solve:

1. $\frac{3}{4} \times \frac{1}{3} = \frac{1}{4}$
2. $\frac{14}{15} \times \frac{2}{7} = \frac{4}{15}$
3. $\frac{1}{8} \times \frac{2}{3} = \frac{1}{12}$
4. $\frac{2}{6} \times \frac{12}{15} = \frac{4}{15}$
5. $\frac{1}{7} \times \frac{7}{8} = \frac{1}{8}$

Lesson Plan # 3

Objective: At the end of the lesson the students will be able to multiply fractions by other fractions.

A.S: Review homework from previous night.

Input: Review with the students the steps to follow when multiplying fractions.
Step #1 – change whole numbers to fractions by using a 1 for the denominator.
Step # 2 – check to see if you can cross-cancel.
Step # 3 – multiply straight across (numerator and denominator)
Step # 4 – reduce all answers.

Modeling: Use the above steps to solve the following multiplication problem for the students:

$$3/8 \times 3 =$$

$$\text{Step \# 1} - 3/8 \times 3/1 =$$

Step # 2 – cannot cross-cancel.

$$\text{Step \# 3} - 3 \times 1 = 9$$

$$8 \times 1 = 8$$

$$= 9/8$$

Step # 4 – 9/8 reduces to $1 \frac{1}{8}$

Guided Practice:

Have the students use the above steps to solve the following problems:

*Problems for the experimental class should be written in blue.

*Problems for the control class should be written in black.

1. $9 \times 4/3 = 6 \frac{3}{4}$

2. $7 \times 2/5 = 2 \frac{4}{5}$

3. $8 \times 5/6 = 6 \frac{2}{3}$

4. $56 \times 2/7 = 16$

5. $72 \times 1/2 = 36$

6. $5/2 \times 11 = 27 \frac{1}{2}$

Checking for Understanding:

Have the students solve the following problems for practice.

1. $7/8 \times 4 = 3 \frac{1}{2}$

2. $5/6 \times 5 = 4 \frac{1}{6}$

3. $3/10 \times 7 = 2 \frac{1}{10}$

4. $2/3 \times 4 = 2 \frac{2}{3}$

5. $4/7 \times 11 = 6 \frac{2}{7}$

Lesson Plan # 4

Objective: At the end of the lesson the students will be able to closely estimate the product of two fractions.

A.S.: Tell the students there will be a quiz on the multiplication and estimation of fractions tomorrow.
Review homework.

Input: Tell the students the rules to use when estimating the product of two fractions.

Rule # 1- Round all mixed numbers.

Rule # 2 – Look for compatible numbers and cross-cancel.

Rule # 3 – Use benchmarks to change fractions to either 1 or $\frac{1}{2}$.

Example: $2\frac{3}{4} \times 5 =$

Rule # 1- $2\frac{3}{4}$ is rounded to 3

$3 \times 5 = 15$

$2\frac{3}{4} \times 5 \sim 15$

Guided Practice:

Tell the students to estimate the products of the following problems by following one of the above rules.

1. $1\frac{1}{8} \times 3\frac{4}{5} =$

Rule # 1 - $1 \times 4 = 4$

$1\frac{1}{8} \times 3\frac{4}{5} \sim 4$

2. $\frac{5}{6} \times 25 =$

Rule # 2 – $\frac{5}{1} \times \frac{4}{1} = 20$

$\frac{5}{6} \times 25 \sim 20$

3. $\frac{8}{9} \times \frac{3}{7} =$

Rule # 3 – $1 \times \frac{1}{2} = \frac{1}{2}$

$\frac{8}{9} \times \frac{3}{7} \sim \frac{1}{2}$

Checking for Understanding:

Have the students estimate the following products and state which rule they used to do so.

1. $\frac{7}{9} \times 10 \sim 7$ (Rule # 2)

2. $7 \times 2\frac{8}{9} \sim 21$ (Rule # 1)

3. $\frac{3}{8} \times 22 \sim 11$ (Rule # 3)

4. $\frac{5}{6} \times 15 \sim 15$ (Rule # 3)

5. $\frac{2}{3} \times 10 \sim 6$ (Rule # 2)

Lesson Plan # 5

Objective: At the end of the lesson the students will be able to multiply mixed numbers by fractions.

A.S.: Review homework with the students.

Input: Tell the students the steps to solving multiplication problems that contain mixed numbers.

Step # 1- Change all mixed numbers to improper fractions.

Step # 2 – Make any whole numbers fractions by placing a 1 in the denominator.

Step # 3 – Check to see if you can cross-cancel.

Step # 4 – Multiply straight across.

Step # 5 - Reduce the answer if necessary.

Modeling:

$$1 \frac{1}{3} \times 6 =$$

*Multiplication problems for the experimental class should be written in blue.

*Multiplication problems for the control class should be written in black.

Remind the students in the experimental class that the blue marker is being used so that means we are solving multiplication problems.

Step # 1 $1 \frac{1}{3} = \frac{4}{3}$

Step # 2 $6 = \frac{6}{1}$

Step # 3 $\frac{4}{3} \times \frac{6}{1} = \frac{4}{1} \times \frac{2}{1}$

Step # 4 $4 \times 2 = 8$ $1 \times 1 = 1$

Step # 5 $\frac{8}{1} = 8$

$$1 \frac{1}{3} \times 6 = 8$$

Guided Practice:

Have the students solve the following problems.

Review the answers and steps used to solve each question on the board.

1. $12 \times 3 \frac{3}{4} = 45$

2. $4 \frac{3}{7} \times 2 = 8 \frac{6}{7}$

3. $7 \times 1 \frac{3}{8} = 9 \frac{5}{8}$

4. $\frac{3}{4} \times 2 \frac{1}{2} = 1 \frac{1}{4}$

5. $3 \frac{1}{5} \times \frac{5}{8} = 2$

Checking for Understanding:

Have the students solve the following problems.

1. $3 \frac{1}{3} \times 5 \frac{2}{5} = 18$

2. $\frac{1}{6} \times 2 \frac{3}{4} = 11/24$

3. $4 \frac{2}{3} \times 3 = 14$

4. $1 \frac{2}{9} \times 2 \frac{2}{5} = 2 \frac{14}{15}$

Lesson Plan # 6

Objective: At the end of the lesson the students will be able to practice multiplying fractions by fractions, fractions by whole numbers, mixed numbers by mixed numbers, and mixed numbers by whole numbers.

A.S.: Review homework with the students.

Input:

Have the students review the steps needed in order to solve problems that involve the multiplication of fractions.

Step # 1- Change all mixed numbers to improper fractions.

Step # 2 – Make any whole numbers fractions by placing a 1 in the denominator.

Step # 3 – Check to see if you can cross-cancel.

Step # 4 – Multiply straight across.

Step # 5 - Reduce the answer if necessary.

Ask the experimental group: “How do you know we are solving multiplication problems today?” (Using the blue marker)

Continue to use the black marker for the control group.

Guided Practice:

Have the students volunteer to come to the board and solve the following problems.

Have the students at the board explain each step they used to solve the problem.

- In the experimental class all work completed on the board by the students should be done with blue marker.
- In the control class all work completed on the board by the students should be done with black marker.

1. $40 \times 1/5 = 8$
2. $21 \times 1/3 = 7$
3. $35 \times 1/5 = 7$
4. $18 \times 1/2 = 9$
5. $16 \times 1/4 = 4$
6. $12 \times 3/4 = 9$

Checking for Understanding:

Have the students practice by solving the following problems in their notebooks.

1. $18 \times 3/5 = 10 \frac{4}{5}$
2. $21 \times 5/6 = 17 \frac{1}{2}$
3. $64 \times 3/8 = 24$
4. $17 \times 2/3 = 11 \frac{1}{3}$
5. $9 \frac{4}{5} \times 30 = 294$
6. $1/6 \times 9/10 = 3/10$
7. $3 \frac{3}{4} \times 2 \frac{1}{2} = 9 \frac{3}{8}$
8. $8 \times 1 \frac{2}{3} = 13 \frac{1}{3}$

Lesson Plan # 7

Objective: At the end of the lesson the students will be able to solve word problems that require them to 'work backwards'.

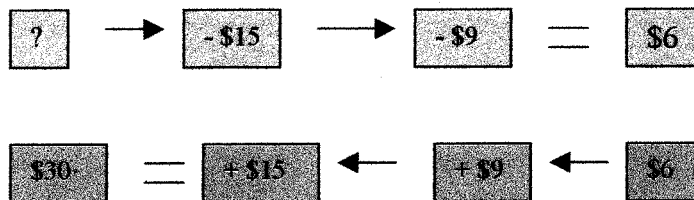
A.S.: Write the following word problem on the board:

Allen went to the store and bought a CD for \$15.00 and a tape for \$9.00. He had \$6.00 in his wallet when he got home. How much did he have before he went to the music store?

Ask the students: "What would be a good strategy to use in order to solve this word problem?" (work backwards).

Input:

Tell the students that there is a very specific way to solve this problem. Show the students the algorithm they are to use in order to solve word problems that require them to work backwards.



Tell the students that the first row of boxes illustrate what happens in the word problem.

Start with a question box because that is the amount we are trying to find. Then show how Allen spent the money. First, Allen spent \$15.00 (subtract), then he spent \$9.00 (subtract). He ended up with \$6.00 (equals).

*For the experimental group these boxes will be green.

* For the control group the boxes remain black.

The boxes on the bottom show the *opposite* of what happens in the boxes above. $\$6.00 + \$9.00 + \$15.00 = \30.00 .

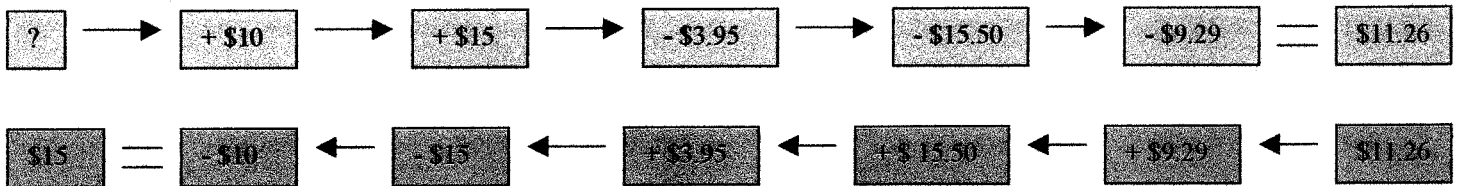
*For the experimental group the bottom boxes are orange (for opposite).

* For the control group the bottom boxes remain black as well.

Checking for Understanding:

Have the students set up the boxes for the following word problem:

Joan received some money from her parents for her birthday. An aunt gave her \$10 and her grandmother gave her \$15. She spent \$3.95 for a scarf, \$15.50 for a skirt, and \$9.29 for a blouse. She had \$11.26 left after her shopping spree. How much money did her parents give her for her birthday?



Remind the students to do the opposite in the bottom boxes.

Solution: $\$11.26 + \$9.29 + \$15.50 + \$3.95 - \$15 - \$10 = \$15$.

Independent Practice:

Have the students create a solve their own 'work backwards' word problem.

Lesson Plan # 8

Objective: At the end of the lesson the students will be able to illustrate the division of fractions by whole numbers.

A.S.: Review with the students the multiplication of fractions.

*The experimental class will see these problems written in blue marker.

*The control class will see these problems written in black marker.

REVIEW:

1. $\frac{2}{3}$ of 21 = 14
2. $\frac{3}{4} \times 24 = 18$
3. $\frac{9}{10} \times \frac{5}{8} = \frac{9}{16}$
4. $1 \frac{2}{3} \times \frac{6}{7} = 1 \frac{3}{7}$
5. $2 \frac{1}{3} \times 2 \frac{1}{2} = 5 \frac{5}{6}$

Input:

Put the following problem on the board.

*For the experimental class all division problems should be written in red.

*For the control class all division problems should be written in black.

$$4 \div \frac{1}{3} =$$

Tell the students in the experimental classroom that all division problems will be written in red.

Ask the students to draw a picture of this problem.



Remind the students that when we multiplied fractions the answers got smaller. ($\frac{1}{2} \times \frac{1}{2} = \frac{1}{4}$)

Ask the students to guess what will happen when we divide fractions.
(answers will get bigger)

Ask the student to look at the picture on the board and see how many $\frac{1}{3}$ there are in 4. (12)

Using the same picture have the students figure how many $\frac{2}{3}$ are in 4 ($4 \div \frac{2}{3} = 6$)

Modeling:

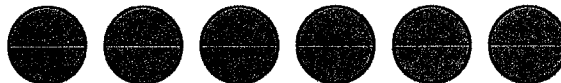
Draw a picture of the following problem on the board: $6 \div \frac{1}{2} =$

Tell the students the steps to illustrating this problem.

Step # 1- Draw 6 objects (6 is the whole number in the problem).

Step # 2 – Divide each object into 2 sections (for $\frac{1}{2}$).

Step # 3 – Count how many $\frac{1}{2}$ there are in 6.

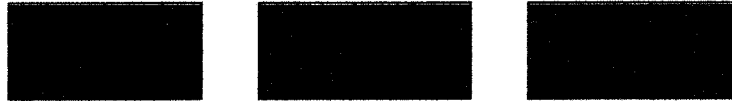


$$6 \div \frac{1}{2} = 12$$

Guided Practice:

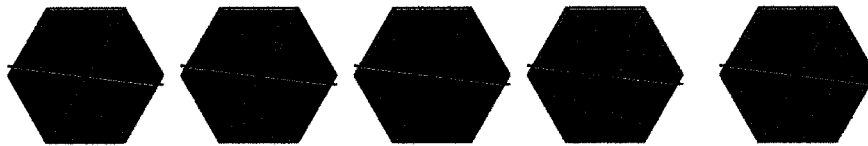
Ask the student to find out how many $\frac{1}{4}$ are in 3 by drawing a picture.
Monitor the room to ensure that each student is following the correct steps.

Show the correct illustration and answer on the board.



$$1/4 \div 3 = 12$$

Have the students illustrate the following problem: $5 \div \frac{1}{8} =$



$$5 \div \frac{1}{8} = 40$$

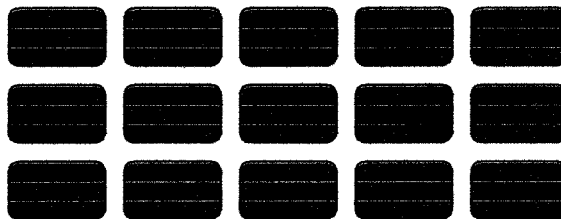
Checking for Understanding:

Have the students illustrate and solve the following problems:

1. $2 \div \frac{1}{2} = 4$



2. $15 \div \frac{1}{3} = 45$



Lesson Plan # 9

Objective: At the end of the lesson the students will be able to divide fractions.

A.S.: Review with the students how to illustrate the division of fractions.
REVIEW:

$$3 \div \frac{1}{3} = 9$$



Input:

Tell the students that it is not always practical to draw a picture in order to solve division problems.

Show the students the steps to solving division of fraction problems.

Step # 1 – Check to see if you can divide straight across.

Step # 2 – If step # 1 is not possible, flip the second fraction and change the sign to multiplication.

Step # 3 – Cross-cancel if possible.

Step # 4 – Multiply straight across.

Step # 5 - Reduce your answer.

*Tell the experimental classroom that when you perform steps # 2-4 we will be using a blue marker on the board. (blue = multiplication)

*The control group should see both the multiplication and division problems written in black marker on the board.

Modeling:

1. $\frac{7}{8} \div \frac{1}{4} =$

Step # 1- 1 goes into 7 (7 times)

4 goes into 8 (2 times)

Step # 4 – $\frac{7}{2} = 3 \frac{1}{2}$

2. $\frac{6}{10} \div \frac{2}{3} =$

Step # 1- Cannot divide across.

Step # 2 – $\frac{6}{10} \div \frac{2}{3} =$ becomes $\frac{6}{10} \times \frac{3}{2} =$

Step # 3 – Cross-cancel the 6 and the 2. $\frac{3}{10} \times \frac{3}{1} =$

Step # 4- $3 \times 3 = 9$ and $10 \times 1 = 10$

Step # 5 – $\frac{9}{10}$ cannot be reduced.

Guided Practice:

Have the students complete the following problems in their notebooks. Ask for volunteers to come to the board and show how they solved the problems.

1. $\frac{4}{2} \div \frac{5}{1} = \frac{2}{5}$

2. $\frac{4}{15} \div \frac{3}{5} = \frac{4}{9}$

3. $\frac{5}{8} \div \frac{3}{2} = \frac{5}{12}$

4. $\frac{2}{6} \div \frac{5}{6} = \frac{2}{5}$

Checking for Understanding:

Have the students solve the following division problems:

1. $3/20 \div 1/5 = 3/4$
2. $10/25 \div 2/25 = 5$
3. $3/5 \div 2/3 = 9/10$
4. $1/3 \div 2/4 = 2/3$
5. $2/3 \div 1/6 = 4$

Independent Practice:

Have the students complete math worksheet on the division of fractions.

Lesson Plan # 10

Objective: At the end of the lesson the students will be able to divide mixed numbers by mixed numbers.

A.S.: Have the students begin class by practicing a 'work backwards' word problem.

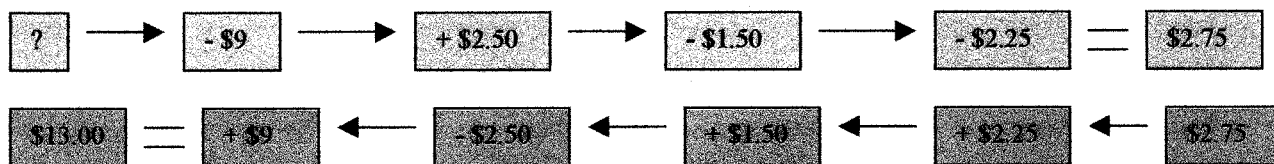
Put the solution on the board so that they can check their work.

*The boxes should be color coded for the experimental group.

*The boxes should be black for the control group.

REVIEW:

John went out to a rodeo with his brother. At the end of the day he had \$2.75 left in his pocket. He had bought two rodeo tickets for his brother and himself for \$9.00. Then he won \$2.50 on a game of chance. He bought a rodeo guidebook for \$1.50 and a bucket of popcorn for \$2.25. How much money did John start out with?



$$\text{Answer} = \$2.75 + \$2.25 + \$1.50 - \$2.50 + \$9.00 = \$13.00$$

Input:

Put the following problem on the board: $5 \frac{2}{3} \div \frac{2}{5} =$

Review with the students the steps to solving a division of fractions problem.

Step # 1 – Check to see if you can divide straight across.

Step # 2 – If step # 1 is not possible, flip the second fraction and change the sign to multiplication.

Step # 3 – Cross-cancel if possible.

Step # 4 – Multiply straight across.

Step # 5 – Reduce your answer.

Tell the students that the only new step in solving this problem is to *first* change any mixed numbers into improper fractions.

Step # 1 - $5 \frac{2}{3} \div \frac{2}{5}$ becomes $17/3 \div \frac{2}{5}$

Step # 2 – cannot divide across

Step # 3- $17/3 \times 5/2 =$

Step # 4- Cannot cross cancel

Step # 5- $17 \times 5 = 85$ and $3 \times 2 = 6$

Step # 6 – $85/6$ becomes $14 \frac{1}{6}$

Guided Practice:

Have the students solve the following problems using the above steps.

Put the correct answers and procedure on the board.

*When the problem requires multiplication blue marker should then be used in the experimental class.

1. $7 \frac{1}{5} \div 2 \frac{7}{10} = 2 \frac{2}{3}$
 $36/5 \div 27/10 =$
 $36/5 \times 10/27 =$
 $4/1 \times 2/3 =$
 $8/3 =$
 $2 \frac{2}{3}$

2. $4 \frac{4}{5} \div 8 = 3/5$
 $24/5 \div 8/1 =$
 $24/5 \times 1/8 =$
 $3/5 \times 1/1 =$
 $3/5$

3. $4 \frac{1}{2} \div 5/6 = 5 \frac{2}{5}$
 $9/2 \div 5/6 =$
 $9/2 \times 6/5 =$
 $9/1 \times 3/5 =$
 $27/5 =$
 $5 \frac{2}{5}$

Checking for Understanding:

Tell the students to practice solving all types of division problems with the following questions:

1. $6/10 \div 2/3 = 9/10$
2. $1/2 \div 1/3 = 1 \frac{1}{2}$
3. $2/6 \div 5/8 = 8/15$
4. $4/5 \div 3/9 = 2 \frac{2}{5}$

Lesson Plan # 11

Objective: At the end of the lesson the students will be able to practice dividing mixed numbers by mixed numbers.
At the end of the lesson the students will be able to practice solving 'work backwards' word problems.

A.S.: Review homework with the students.
Review with the students the steps to solving problems involving the division of mixed numbers.

Step # 1 – Change all mixed numbers to improper fractions.

Step # 2 - Check to see if you can divide straight across.

Step # 3 – If step # 1 is not possible, flip the second fraction and change the sign to multiplication.

Step # 4 – Cross-cancel if possible.

Step # 5 – Multiply straight across.

Step # 6 - Reduce your answer.

Input:

Remind students how to divided mixed numbers by modeling the following problem:

- For the experimental class all division problems should be written in red and multiplication problems should be written in blue.
- For the control class all problems should be written in black.

$$2 \frac{1}{2} \div 1 \frac{2}{4} =$$

$$5/2 \div 6/4 =$$

$$5/2 \times 4/6 =$$

$$5/1 \times 2/6 =$$

$$10/6 =$$

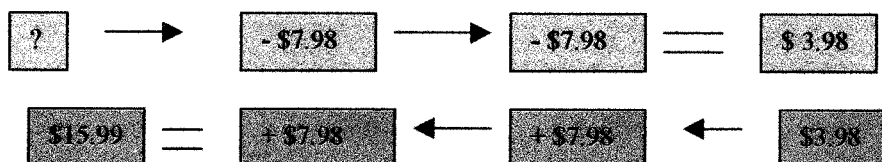
$$1 \frac{4}{6} =$$

$$1 \frac{2}{3}$$

Remind the students how to solve 'work backwards' word problems by modeling the following:

- For the experimental class the first row of boxes should be green and the bottom row of boxes should be written in orange.
- For the control class all problems should be written in black.

Floyd had \$3.25 after leaving the toy shop. He had just bought 2 games at \$7.98 each. How much money did he have before buying the games?



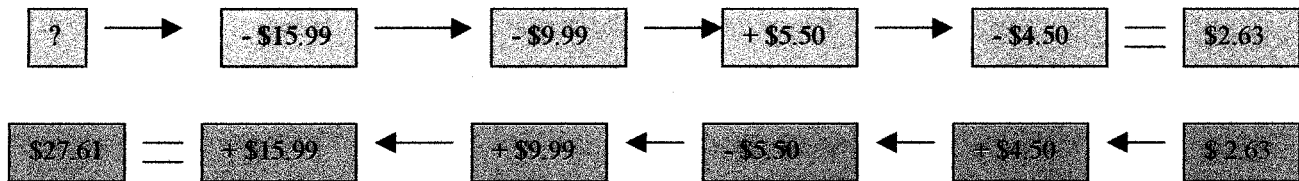
Checking for Understanding:

Have the students practice dividing fractions by solving the following problems:

1. $2 \frac{1}{4} \div 1 \frac{3}{4} = 1 \frac{2}{7}$
2. $3 \frac{1}{2} \div 1 \frac{1}{2} = 2 \frac{1}{3}$
3. $5 \frac{4}{5} \div 2 \frac{3}{5} = 2 \frac{3}{13}$
4. $6 \frac{1}{3} \div 2 \frac{2}{3} = 2 \frac{3}{8}$
5. $3 \frac{3}{4} \div 1 \frac{1}{2} = 2 \frac{1}{2}$
6. $4 \frac{1}{2} \div 3 \frac{3}{4} = 1 \frac{1}{5}$
7. $7 \frac{1}{5} \div 2 \frac{7}{10} = 2 \frac{2}{3}$

Have students practice solving 'work backwards' word problems by solving the following:

Billie Sue returned from the mall with \$2.63 in her pocket. At the mall she bought a CD for \$15.99 and a necklace for \$9.99. She returned a shirt for \$5.50 and bought a snack and a drink for \$4.50. How much did she have on her way to the mall?



Lesson Plan # 12

Objective: At the end of the lesson the students will be able to practice multiplying and dividing fractions.

A.S.: Have the students warm-up for class by solving the following 'work backwards' word problem:

Scott went to the mall last Saturday. He returned a shirt for \$16.99 and some sneakers that cost \$54.99. Then he bought a video game for \$39.99 and a CD for \$15.99. Last, he got a snack of 2 pretzels for \$2.59 each. He came home with \$37.95 in his pocket. How much did he have before he went to the mall?

$$\boxed{?} \rightarrow \boxed{+ \$16.99} \rightarrow \boxed{+ \$54.99} \rightarrow \boxed{- \$39.99} \rightarrow \boxed{- \$15.99} \rightarrow \boxed{- \$5.18} = \boxed{\$32.85}$$

$$\boxed{\$22.03} = \boxed{- \$16.99} \leftarrow \boxed{- \$54.99} \leftarrow \boxed{+ \$39.99} \leftarrow \boxed{+ \$15.99} \leftarrow \boxed{+ \$5.18} \leftarrow \boxed{\$32.85}$$

Input:

Review with the students the steps to solving problems that involve the multiplication of fractions.

Write these steps on the board:

Step #1 – change whole numbers to fractions by using a 1 for the denominator.

Step # 2 – check to see if you can cross-cancel.

Step # 3 – multiply straight across (numerator and denominator)

Step # 4 – reduce all answers.

Example: $9 \times \frac{4}{3} =$
 $\frac{9}{1} \times \frac{4}{3} =$
 $\frac{3}{1} \times \frac{4}{1} =$
 12

Review with the students the steps to solving problems that involve the division of fractions.

Write these steps on the board:

Step # 1 – Change all mixed numbers to improper fractions.

Step # 2 - Check to see if you can divide straight across.

Step # 3 – If step # 1 is not possible, flip the second fraction and change the sign to multiplication.

Step # 4 – Cross-cancel if possible.

Step # 5 – Multiply straight across.

Step # 6 - Reduce your answer.

Example: $2 \frac{1}{2} \div 1 \frac{2}{4} =$
 $\frac{5}{2} \div \frac{6}{4} =$
 $\frac{5}{2} \times \frac{4}{6} =$
 $\frac{5}{1} \times \frac{2}{6} =$
 $\frac{10}{6} =$
 $1 \frac{4}{6} =$
 $1 \frac{2}{3}$

Checking for Understanding:

Tell the students to practice multiplying and dividing fractions by solving the following problems.

Review answers and procedures with the students.

- Practice questions in the experimental class should be written in blue for multiplication problems, and red for division problems.
- Practice questions in the control class should be written in black.

1. $2 \frac{1}{2} \div 1 \frac{3}{4} =$
 $\frac{5}{2} \div \frac{7}{4} =$
 $\frac{5}{2} \times \frac{4}{7} =$
 $\frac{5}{1} \times \frac{2}{7} =$
 $\frac{10}{7} =$

2. $4 \frac{4}{5} \div 2 \frac{1}{5} =$
 $\frac{24}{5} \div \frac{11}{5} =$
 $\frac{24}{5} \times \frac{5}{11} =$
 $\frac{24}{1} \times \frac{1}{11} =$
 $\frac{24}{11} =$
 $2 \frac{2}{11}$

3. $5 \frac{1}{4} \div 2 \frac{3}{4} =$
 $\frac{21}{4} \div \frac{11}{4} =$
 $\frac{21}{4} \times \frac{4}{11} =$
 $\frac{21}{1} \times \frac{1}{11} =$
 $\frac{21}{11} =$

4. $\frac{7}{8} \times \frac{5}{14} =$
 $\frac{1}{8} \times \frac{5}{2} =$
 $\frac{5}{16}$

5. $2 \frac{2}{8} \times 5 \frac{5}{6} =$
 $\frac{18}{8} \times \frac{35}{6} =$
 $\frac{3}{8} \times \frac{35}{1} =$
 $\frac{105}{8} =$
 $13 \frac{1}{8}$

Lesson Plan # 13

Objective: At the end of the lesson the students will be able to review how to multiply, divide, and estimate fractions in order to prepare for a unit test.

A.S.: Review homework with the students.
Remind students that there will be a unit test on multiplying, dividing, and estimating fractions as well as a 'work backwards' word problem.

Input:

Review the steps to dividing fractions with the students.

Step # 1 – Change all mixed numbers to improper fractions.

Step # 2 - Check to see if you can divide straight across.

Step # 3 – If step # 1 is not possible, flip the second fraction and change the sign to multiplication.

Step # 4 – Cross-cancel if possible.

Step # 5 – Multiply straight across.

Step # 6 - Reduce your answer.

Review the steps to multiplying fractions with the students.

Step #1 – change whole numbers to fractions by using a 1 for the denominator.

Step # 2 – check to see if you can cross-cancel.

Step # 3 – multiply straight across (numerator and denominator)

Step # 4 – reduce all answers.

Review the rules to estimating the multiplication of fractions with the students.

Rule # 1- Round all mixed numbers.

Rule # 2 – Look for compatible numbers and cross-cancel.

Rule # 3 – Use benchmarks to change fractions to either 1 or 1/2.

Checking for Understanding:

Have the students practice dividing fractions by solving the following problems.

Review all answers with the students.

- In the experimental class the following colors should be used: division problems should be written in red, multiplication problems should be written in blue, and in 'work backwards' word problems the top boxes should be green and the bottom boxes should be orange.
- All problems should be written in black for the control class.

Divide:

1. $6 \div \frac{1}{3} =$
 $\frac{6}{1} \times \frac{3}{1} =$
18

2. $3/4 \div 5/8 =$
 $3/4 \times 8/5 =$
 $3/1 \times 2/5 =$
 $6/5 =$
 $1/5$
3. $2 \frac{1}{8} \div 1 \frac{1}{4} =$
 $17/8 \div 5/4 =$
 $17/8 \times 4/5 =$
 $17/2 \times 1/5 =$
 $17/10 =$
 $1 \frac{7}{10}$

Multiply:

1. $1/3$ of $12 = 4$
2. $3/5$ of $20 = 12$
3. $7/8$ of $64 = 56$
4. $2/3 \times 9/20 =$
 $2/1 \times 3/20 =$
 $6/20 =$
 $2/10 =$
 $1/5$
5. $6/7 \times 2 =$
 $6/7 \times 2/1 =$
 $12/7 =$
 $5/7$
6. $5 \times 20/25 =$
 $5/1 \times 20/25 =$
 $1/1 \times 20/5 =$
 $20/5 =$
 4

Estimate:

1. $5 \times 35 =$
Rule # 3
 $5/1 \times 6/1 =$
 30
2. $2 \frac{2}{8} \times 5 \frac{5}{6} =$
Rule # 1
 $2 \times 6 =$
 12

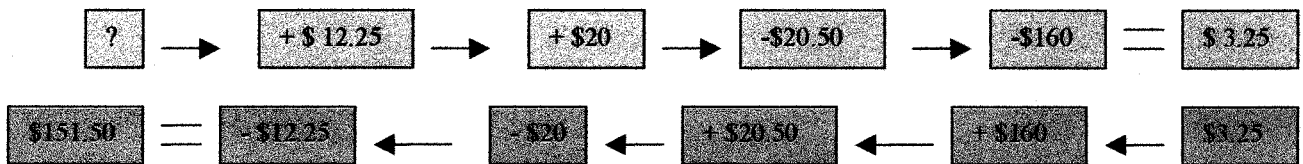
$$\begin{array}{r}
 3. \quad 7/8 \times 60 = \\
 \text{Rule \# 3} \\
 \times 60 = \\
 60
 \end{array}$$

$$\begin{array}{r}
 4. \quad 5/12 \times 30 = \\
 \text{Rule \# 3} \\
 1/2 \times 30 = \\
 15
 \end{array}$$

$$\begin{array}{r}
 5. \quad 7/8 \times 5/12 = \\
 \text{Rule \# 3} \\
 1 \times 1/2 = \\
 1/2
 \end{array}$$

Work Backwards:

John went to the hockey game last week. His dad gave him \$12.25 for food. His mom gave him \$20.00 for his allowance. At the game John payed \$12.00 for parking, \$5.00 for a large soda and \$3.50 for a pretzel. Tickets for the game cost \$80.00 each, and John bought two at the door. At the end of the game John had \$3.25 left in his pocket. How much did he start with before his parents gave him money?



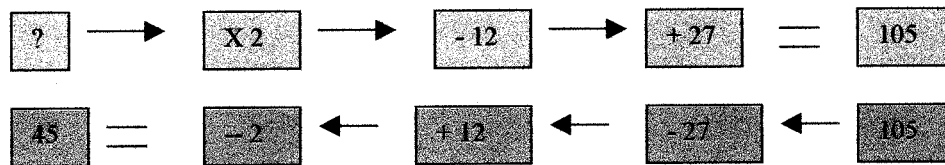
Lesson Plan # 14

Objective: At the end of the lesson the students will be able to practice the multiplication, division and estimation of fractions in order to prepare for a unit test.

A.S.: Have the students solve the following 'work backwards' word problem:

- For the experimental class the top boxes should be written in green and the bottom boxes should be written in orange.
- For the control class all boxes should be written in black.

Sally entered a marble contest yesterday. At the beginning of the contest she doubled her amount of marbles. Then, she lost 12 marbles. Next, she won 27 marbles. Sally left the contest with 105 marbles. How many did she have when she started the contest?



Input:

Show the students the answer and procedure for the warm up problem.
Review the procedure for solving 'work backwards' word problems if the students are having difficulty.
Ask the students if they have any questions on how to multiply, divide or estimate fractions.
Review any steps or rules that may confuse them.

Checking for Understanding:

Have the students review for their test by practicing with the following questions.

- In the experimental class the following colors should be used: division problems should be written in red, and multiplication and estimation problems should be written in blue.
- All problems should be written in black for the control class.

Multiply:

1. $6 \frac{1}{3} \times 2 \frac{2}{5} =$
 $19/3 \times 12/5 =$
 $19/1 \times 3/5 =$
 $57/5 =$
 $11 \frac{2}{5}$

2. $\frac{1}{4}$ of 24 = 6
3. $5 \times 1 \frac{1}{2} =$
 $\frac{5}{1} \times \frac{3}{2} =$
 $\frac{15}{2} =$
 $7 \frac{1}{2}$
4. $3 \frac{13}{7} \times 2 \frac{2}{8} =$
 $\frac{24}{8} \times \frac{18}{8} =$
 $\frac{3}{8} \times \frac{18}{1} =$
 $\frac{54}{8} =$
 $6 \frac{6}{8} =$
 $6 \frac{3}{4}$

Divide:

1. $2 \frac{1}{3} \div 1 \frac{1}{6} =$
 $\frac{7}{3} \div \frac{7}{6} =$
 $\frac{7}{3} \times \frac{6}{7} =$
 $\frac{1}{1} \times \frac{2}{1} =$
 2
2. $\frac{1}{9} \div \frac{2}{3} =$
 $\frac{1}{9} \times \frac{3}{2} =$
 $\frac{1}{3} \times \frac{1}{2} =$
 $\frac{1}{6}$
3. $6 \frac{1}{3} \div 2 \frac{4}{6} =$
 $\frac{19}{3} \div \frac{16}{6} =$
 $\frac{19}{3} \times \frac{6}{16} =$
 $\frac{19}{1} \times \frac{2}{16} =$
 $\frac{38}{16} =$
 $2 \frac{6}{16} =$
 $2 \frac{3}{8}$
4. $5 \div 1 \frac{1}{4} =$
 $\frac{5}{1} \div \frac{5}{4} =$
 $\frac{5}{1} \times \frac{4}{5} =$
 $\frac{1}{1} \times \frac{4}{1} =$
 4

Estimate:

1. $3 \frac{1}{8} \times 5 \frac{4}{5} =$
Rule # 1
 $3 \times 6 =$
 18

2. $\frac{4}{5} \times 31 =$
Rule # 2
 $\frac{4}{5} \times \frac{30}{1} =$
 $\frac{4}{1} \times \frac{6}{1} =$
24
3. $\frac{4}{5} \times 32 =$
Rule # 3
 $1 \times 32 =$
32
4. $\frac{1}{8} \times \frac{2}{3} =$
Rule # 3
 $1 \times \frac{1}{2} =$
 $\frac{1}{2}$

Independent Practice:

Assign students more practice questions to be completed at home in order to prepare them for tomorrow's test.

VITA

Name and Place of Birth:

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